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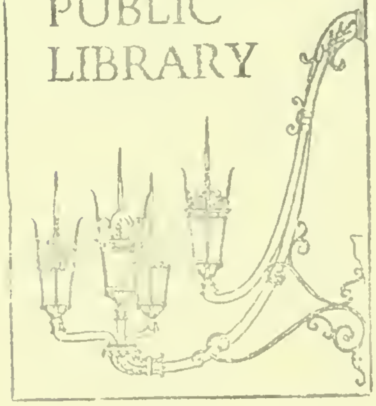

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WALDEN RESEARCH

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Mr. James W. Hotaling
The Saratoga Associates
The Arcade
Saratoga Springs, New York 12866

Dear Mr. Hotaling:

Walden Research Division of Abcor, Inc., is pleased to submit this proposal for a preliminary assessment of the air quality impact associated with the Park Plaza Project in Boston, Massachusetts.

Our scope and approach, estimated costs, and other contractual items are detailed below.

SCOPE AND APPROACH

The approach we plan to apply to this project consists of relative impact evaluation based on modeling studies of the impact of carbon monoxide emissions associated with changes in motor vehicle traffic which will arise from several build option alternatives for the project.

The proposed work will consist of the following basic tasks outlined below:

IMPACT ASSESSMENT

1. The initial step will consist of the acquisition of pertinent automotive traffic and meteorological data, and the preparation of these acquired data into a format which will be compatible with the modeling task. It is agreed that Saratoga Associates will furnish our staff with appropriate average daily traffic (ADT) and peak traffic data for the affected local roadways. This data and required format will be specified on receipt of your authorization to proceed.

2. Estimates of air pollutant emissions from automotive traffic will be calculated for the no-build case and up to four project design alternatives. These estimates will be made for the present time for the no-build case, and for two future design years corresponding to the estimated time of completion of the build alternatives (ETC) and a future design year. All assumptions used in generating the necessary data will be documented.

201 Vassar Street Cambridge Massachusetts 02139 617/868/3940
WALDEN RESEARCH DIVISION OF Abcor Inc

3. A simple atmospheric diffusion model developed by the State of California Department of Public Works Highway Division will be employed to estimate changes in ambient air quality arising from the contaminant emissions calculated above. This mathematical line source model is based on the Gaussian plume configuration and assumes an initial roadway mixing cell.

REPORT

4. The final task consists of the analysis of the modeling results in the form of a technical report. The model predictions will be used to rank and evaluate the relative impacts on air quality of the various project design alternatives (including the no-build alternative). The summary report will also document all assumptions and techniques used in the modeling analysis.

COST AND DURATION

The estimated costs for our professional services are based on our established rates for both time and materials. In addition, we would expect reimbursement, including a 20% handling charge, of such disbursed expenses as Materials and Supplies, Travel and Communications. Our estimated project cost is $3,000. This cost estimate is valid for a 90-day period, after which time we reserve the right to make adjustments for changes in labor rates and disbursed expense costs.

It is anticipated that the duration of the work will be negotiated after receipt of your authorization to proceed.

STAFF RESPONSIBILITY

I will be responsible for the project at Walden. Associated with me will be other professionals with backgrounds appropriate to project tasks. We will look to you or someone designated by you for coordination and guidance on behalf of The Saratoga Associates.

GENERAL PROVISIONS

Invoices will be submitted at the end of each calendar month, and will be payable on receipt.

Our agreement may be terminated on thirty days' written notice by either party or in such lesser time as we find necessary to conclude the work underway at the time of termination notice and report our findings to you. All charges incurred up to the effective date of termination shall be billed to you.

QUALIFICATIONS

Walden has completed similar impact assessment assignments for private, industrial, and federal agencies, including the redevelopment of the Charlestown Navy Yard (Boston, Mass.), the J. F. Kennedy Memorial Library Complex (Cambridge, Mass.), and the proposed depression of the Central Artery (Boston, Mass.). We have extensive background and competent professionals in handling a program such as this, as well as most other aspects of air pollution control. The resumés of key participants in the proposed program are attached to this proposal, along with a more comprehensive statement of our qualifications.

ACCEPTANCE

Should the proposal meet your approval, we are prepared to initiate work on the receipt of the copy enclosed, signed by your authorized representative.

The terms and conditions of any contract resulting from this proposal shall include only: (1) the terms and conditions set forth herein, and (2) such other terms and conditions, if any, as may be proposed by Buyer and accepted in writing by Walden.

We look forward to working with you and your staff on this project.

Very truly yours,

Peter H. Guldberg

Peter H. Guldberg
Atmospheric Scientist

PHG:ek
Enclosure

Approved for Walden Research Division of Abcor, Inc.	Accepted for The Saratoga Associates
[illegible] Signature	Signature
Vice President Title	Title
[illegible] Date	Date

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QUALIFICATIONS

A. GENERAL CORPORATE STATEMENT

Walden Research Division of Abcor Inc. was organized in April 1968 as Walden Research Corporation to provide services to both industry and government in environmental science and technology, specializing in air pollution control. In May 1973, Walden Research Corporation was merged into Abcor, Inc. Abcor manufactures equipment for water treatment, based primarily on membrane technology, using ultrafiltration and reverse osmosis techniques. Abcor also carries out research and development in water pollution control, membrane processes, and bioengineering for a wide variety of agencies.

Walden services offered include consultation, surveys, and contract research and development. Walden's staff is composed of 57 full-time employees, including 39 professionals, each of whom has been carefully selected to contribute to the mix of background required for environmental studies. Their training has been in the following engineering and scientific disciplines:

- Analytical Chemistry
- Chemical Engineering
- Combustion Technology
- Computer Simulation
- Data Processing
- Economics
- Geology
- Industrial Hygiene
- Instrumentation
- Legislation Review
- Meteorology
- Operations Research
- Physical Chemistry
- Physics
- Pollution Control
- Public Policy
- Statistical Analysis
- Systems Analysis
- Urban Studies
- Water Quality

Walden Federal Government clients include the General Services Administration, the Environmental Protection Agency, the Department of Defense, the Department of Commerce, NASA, the Federal Energy Office (now FEA), and the Bureau of Mines.

We have provided services to a number of state agencies within the last few years including Rhode Island, Connecticut, Delaware, Indiana, Illinois, Maine, Massachusetts, New Hampshire, and Vermont. Walden also provides consulting services on environmental impact assessment and control to private industrial clients.

The management and principal technical staff of Walden have had many years' experience in the performance and administration of government R&D programs as evidenced by the discussion of our specific experience given below.

B. SPECIFIC RELATED EXPERIENCE

Most relevant to the current project is Walden's continuous involvement in the preparation of air quality impact statements for governmental agencies, transportation planners, architects, airport authorities and major utilities companies. These impact statements encompass a whole spectrum of emission source characteristics including new highway constructions, major corridor alternatives, bridges, large complex national airports (including J.F. Kennedy, Chicago O'Hare, and Los Angeles International), power plants and other stationary industrial sources, as well as indirect sources such as shopping centers and new office complexes. Two primary factors contribute to our record of successful preparation of such draft impact statements. The first is related to our intimate knowledge of the requirements of an adequate impact statement as stipulated by regional EPA offices. The other factor is associated with our broad experience in this area and a number of operating software packages which have been designed by our own staff for specialized applications. This experience will be of great assistance in evaluating the air quality impacts associated with the proposed project. A summary of our relevant experience from current and past projects within the last three years in environmental impact statements is shown in Table 1.

TABLE 1

REPRESENTATION SAMPLING OF ENVIRONMENTAL IMPACT STATEMENTS

Environmental impact statement for relocation of Route 2 in Greenfield, Massachusetts (Frederic R. Harris, Inc.)

Environmental impact statement for section of Route 52 (I-190) in Leominster, Massachusetts (Universal Engineering Corp.)

Determine impact of several alternative designs for Routes I-86 and I-84 in E. Hartford, Connecticut (Chas. A. Maguire)

Environmental impact statement for Route 52 (I-190) in Worcester - West Boylston - Sterling, Massachusetts (C.E. Maguire)

Appendix summary material for environmental impact statements on I-84 and I-86 in E. Hartford, Connecticut (Close, Jensen & Miller)

Impact statement for Route 9 - Speen Street Intersection in Natick, Massachusetts (Tippets-Abbet-McCarthy-Stratton)

Environmental impact statement for I-391 in Holyoke and Chicopee, Massachusetts (Sverdrup & Parcel and Associates, Inc.)

Response to review comments on impact statement Route 52 (I-90) at Indian Lake, Worcester, Massachusetts (C.E. Maguire)

North Terminal impact study in Boston, Massachusetts (Wallace, Floyd & Ellenzweig)

Impact study of petrochemical (PVC) complex in Curacau (Netherlands Government)

Preliminary impact study of Central Artery depression in Boston, Massachusetts (Wallace, Floyd & Ellenzweig)

Impact study for Kennedy Memorial Library in Cambridge, Massachusetts (C.E. Maguire)

Impact study for Petersburg power plant addition in Petersburg, Indiana (Gibbs & Hill)

Impact statement on Syracuse Airport modification in Syracuse, New York (Bolt, Beranek & Newman, Inc.)

TABLE 1
(CONTINUED)

Impact statement of HUD redevelopment in Hull, Massachusetts (Metcalf & Eddy)

Negative declaration statement for Kennedy Memorial Highway in New Bedford, Massachusetts (Tibbetts Engineering)

Indirect source impact assessment for bulk mail postal facility in Springfield, Massachusetts (United Engineers)

Impact study for new power plant at Ssukunshen, Taiwan (Gibbs & Hill)

Impact study for new coal-fired power plant at White Bluff, Arkansas (Chas. T. Main)

One recent indirect source project which has been very much in the news is the J.F. Kennedy Memorial Library Complex proposed to be located near Harvard Square, Cambridge, Massachusetts. Walden Research, through subcontract with C.E. Maguire, Inc. of Waltham, Massachusetts, prepared the air quality impact portion of the required Environmental Impact Statement (EIS) for GSA. The objective of the impact analysis performed for the J.F.K. Library EIS was to evaluate the maximum carbon monoxide (CO) levels which could arise as a consequence of both adverse meteorological conditions and peak roadway traffic in the project area. Detailed modeling simulations were conducted for the estimated year of completion of the Library Complex (1978) and for a future design year (1981). Comparisons were made between the Build and No-Build situations to evaluate the differential impact of the project on community air quality. The principal elements of the study were a model sensitivity analysis, model validation and calibration, a summary of emissions in the project area, and predictions of CO concentrations and their relation to ambient air quality standards. A seperate air quality monitoring program was undertaken to support the model validation. All predicted CO concentrations were determined using the APRAC-1A urban diffusion model. A computer program, VEHEMI, based on established EPA emissions estimation procedures, was integrated into the model to more accurately determine CO emission rates for a specified motor vehicle model year mix. Recent changes in Federal motor vehicle emission standards and the effects of retrofit devices to be installed under the Boston Transportation Control Plan were incorporated into estimates of future emissions. A copy of a paper to be presented by Walden at the 68th National meeting of the Air Pollution Control Association (APCA), detailing the scope and results of the modeling program undertaken as part of the air impact analysis, is appended to this proposal.

The VEHEMI computer program developed by members of the Walden staff uses EPA's tabulation of automotive exhaust emission factors to provide an analysis of automotive exhaust emissions for use in the evaluation of automotive control strategies in urban areas. This analysis considers such factors as vehicle type, model year, deterioration, travel speed dependence, etc., to account for:

(1) Vehicle population mix (model year and age)
(2) Speed distribution by facility (roadway) type
(3) Deterioration factors as a function of model year and age
(4) Differential travel by age groups
(5) Crankcase and evaporative hydrocarbon emissions.

Members of the Walden staff have also participated in development of the basic set of emission factors used by EPA to establish the proposed standards for control of air pollution from aircraft and aircraft engines.

Walden's experience in emission factors also includes the analysis of stationary combustion sources such as boilers required to satisfy heating and ventilation requirements. As part of a control strategy study for fuel burning sources in the Metropolitan Boston area for EPA, we conducted a detailed review of particulate emission factors for fuel oil and natural gas combustion. An analysis was made of test results from recent research programs and data accumulated by discussions with representatives of the Environmental Protection Agency, the American Petroleum Institute, the National Oil and Fuel Institute, various manufacturers, vendors, and users of the appropriate combustion equipment, and appropriate state and Federal agency personnel concerned with inspection and regulation of fossil fuel utilization facilities. A revised set of factors were structured to differentiate according to unit size and type and to reflect local rather than national boiler unit populations.

Walden has extensive experience in the development and use of emission source inventories. The projects shown in Table 2 emphasize our recent experience in the development of both point and area source data for several regulatory agencies, including the State of Massachusetts (Projects A-3 and A-8). The emission surveys conducted by Walden have often been the initial step in further applications toward a specific analysis objective. Frequently, the application has been to serve as input data to atmospheric diffusion modeling studies in evaluating the impact of alternative regional SO_2 and particulate control strategies. Table 3 presents a list of such applications performed recently by Walden Research. These regional studies consisted of extensive application of the Air Quality Display Model (AQDM) developed under EPA sponsorship, and has provided us with detailed familiarity of input data requirements. Note especially, project B-1, which involved assistance to the State of Massachusetts Bureau of Air Quality Control in development and evaluation of various control strategies required for development of their statewide implementation plan for the Clean Air Act. More recently, Walden has performed several modifications to this basic computer program to introduce recent advances in the state-of-the-art, to provide greater application flexibility, and to improve the efficiency of the computer execution time. This modified version is currently resident in our disk storage library. In addition, we possess the IPP computer program at Walden and supporting program documentation.

In another recent study for EPA, we conducted a review and evaluation of air quality monitoring activities in Massachusetts, and 15 other Northeastern and mid-Atlantic states. This review provided Walden with an up-to-date data base of monitoring activities in each state including tabulations of sites, what pollutants are monitored at these sites and raw data summaries for each site. The data collected for Rhode Island will be of particular utility in projecting measured air quality to an annual basis.

TABLE 2

RELEVANT ASSIGNMENTS IN THE DEVELOPMENT OF EMISSION SOURCE INVENTORIES FOR REGULATORY AGENCIES

Reference	Client	Assignment
A-1	EPA	Computer Process State of Connecticut Emission Inventory
A-2	EPA	Emission Inventory for the State of New Hampshire
A-3	EPA	Emission Inventory for the Commonwealth of Massachusetts
A-4	EPA	Update of Emission Inventory for the Metropolitan Boston AQCR
A-5	EPA	Emission Inventory for Metropolitan Providence AQCR
A-6	EPA	Emission Inventory for the Metropolitan Boston Air Pollution Control District
A-7	EPA	Upgrade NEDS Data for New Hampshire, Maine, Vermont and Delaware
A-8	EPA	Upgrade NEDS Data for Massachusetts and Rhode Island

TABLE 3

RELEVANT ASSIGNMENTS IN THE USE OF EMISSION SOURCE INVENTORIES

Reference	Client	Assignment
B-1	EPA	Control Plan for State of Rhode Island
B-2	EPA	Implementation Plan for State of Maine
B-3	Comm. of Massachusetts	A System for Evaluating Abatement Control Strategies
B-4	EPA	Evaluation of Particulate Control Strategies
B-5	EPA	Modeling Analysis of Power Plants for Compliance Extensions in 51 AQCRs
B-6	EPA	Assistance to EPA in Modeling of Selected Power Plants for Fuel Conversion
B-7	EPA	Air Quality Impact of the Energy Shortage
B-8	EPA	Operations Modeling of Selected Power Plant
B-9	FEO	An Evaluation of the Feasibility of Using NEDS Data for Verifying Reported Energy Consumption in Industry

Other areas which must be considered in the impact analysis include review of the potential effect of the transportation control plan for the Metropolitan Boston area and the Air Quality Maintenance Plan (AQMP) under development for the State of Massachusetts . As you are aware, the initial transportation plans have met considerable opposition from most communities, both from the standpoint of technical validity and feasibility of implementation. This is particularly the case in Metropolitan Boston. Walden is currently engaged in a reexamination of relevant data with the objective of developing a more viable plan for Boston. Air Quality Maintenance Plans are required by EPA in those regions of the country where air quality standards are projected to be exceeded for any of the six criteria pollutants by 1985. Walden is currently completing the first phase of a study for EPA - Region I (Boston) to assist the Commonwealth of Massachusetts in the development of their area source fuel use and emission inventory for use in developing the state's AQMP. The second phase of this study, involving control strategy evaluation, will be conducted by Walden starting later this spring together with similar analyses for Rhode Island and Connecticut. The Massachusetts program will involve development of the data subsequently required to analyze the potential effect of the Massachusetts AQMP on motor vehicle activities in the project area.

Finally, as part of a current major project for EPA, Walden is utilizing atmospheric diffusion modeling and statistical techniques to assess the impact on SO_2 and particulate levels arising directly from the current energy shortage. This study is being conducted on a test case basis for the Metropolitan Boston AQCR.

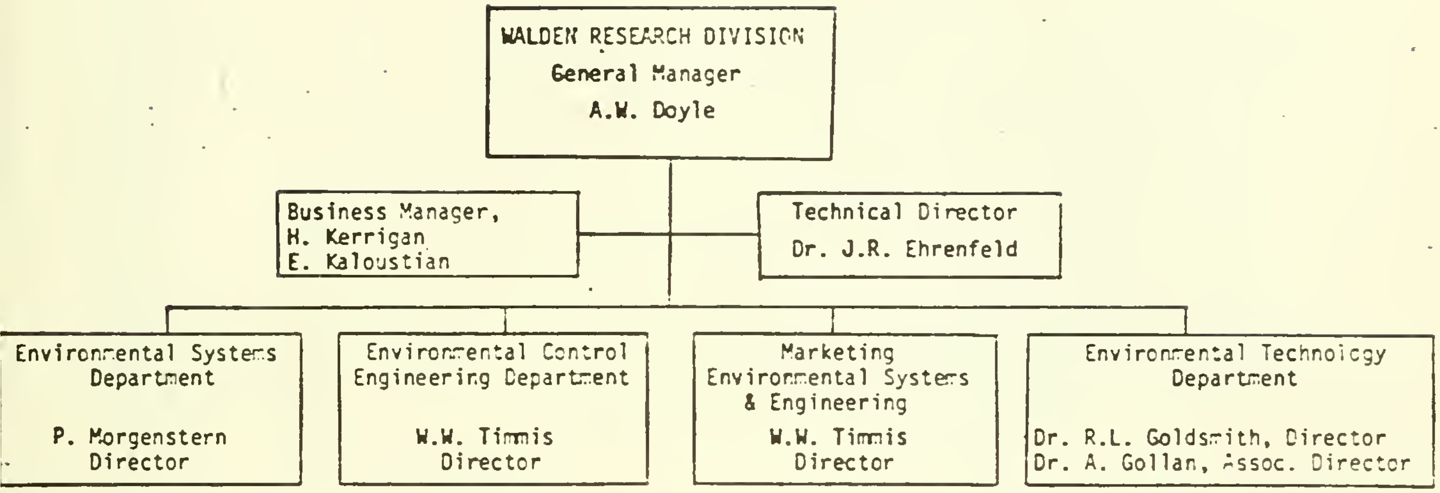
C. MANAGEMENT, ORGANIZATION AND ADMINISTRATION

1. Walden Organization

Walden considers effective management of contract R&D programs to be of paramount importance and has structured its organization to facilitate project management, control and communication. The administrative organization of Walden is shown in Figure 1. This organizational structure provides a flexible system for assembling multi-discipline project staffs and has been particularly effective for programs which require achievement of goals over short periods of time.

Mr. Arnold W. Doyle, Vice-President and General Manager of the Walden Research Division, is responsible for all operations activities at Walden. He has many years of experience in the performance and administration of government R&D programs. To lend management support, weekly contract status reports, showing the previous week's labor distribution and other direct costs, are provided to the program manager by Mr. Harry Kerrigan. A more extensive report is prepared monthly, showing both expenditures and remaining funds in every significant expense category, e.g., labor, travel, materials, computer, etc. In addition to internal discussions on specific technical problem areas, technical and financial reviews on a given project are held monthly with our Technical Director, Dr. John Ehrenfeld.

We believe that the organization, management, and technical skills available at Walden facilitate the structuring and staffing of task order project teams to complete specific assignments. The project-oriented approach has proven effective time and time again and has been demonstrated in numerous quick-response projects described in this section.


WALDEN RESEARCH DIVISION
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A.W. Doyle
Business Manager,
H. Kerrigan
E. Kaloustian
Technical Director
Dr. J.R. Ehrenfeld
Environmental Systems Department
P. Morgenstern
Director
Environmental Control Engineering Department
W.W. Timmis
Director
Marketing Environmental Systems & Engineering
W.W. Timmis
Director
Environmental Technology Department
Dr. R.L. Goldsmith, Director
Dr. A. Gollan, Assoc. Director

PROJECTS STAFF

Program Managers

- K.M. Chng
- J. Fitzpatrick
- Dr. L. Morgenstern
- P. Morgenstern
- Dr. R.D. Siegel

Staff

- F. Benesh
- R. Buerschaper
- T. Curtin
- D. Dorman
- L. Fereshetian
- P. Guldberg
- B. Kemerer
- K. Kennedy
- Dr. S. Khanna
- J. Myers
- J. Sacco
- M. Shah
- K. Wiltsee

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- A. Moniz

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- C. Durkay
- G. Freedland
- D. Grant
- P. Hoover
- C. Jasmin
- M. Kleper
- M. Levy
- R. Lisk
- M. Meservey
- J. Wheelock
- H. Wood
- A. Zakak

Office

- V. Buckley
- V. Burke

November 1, 1974

Figure 1. Walden Research Division Organization Chart

2. Project Management and Technical Direction

The proposed Program Manager and Principal Investigator is Mr. Peter H. Guldberg. Mr. Guldberg is an Atmospheric Scientist with extensive training and experience in diffusion modeling, air quality impact evaluation, statistics and applied mathematics. Mr. Guldberg was responsible for the air quality impact modeling program of the J.F. Kennedy Memorial Library Complex EIS. Most recently, he has conducted a statistical analysis of the impact of the energy shortage on ambient air quality levels in the Metropolitan Boston area for EPA. Mr. Guldberg is currently program manager for an EPA Basic Ordering Agreement task order to assist the State of Rhode Island in preparation of an Air Quality Maintenance Plan.

D. KEY PERSONNEL

In addiition to the Program Manager and the Technical Director named above, other members of the Walden staff with expertise in pertinent areas will also contribute to this program. Technical contributions will, therefore, also come from the following personnel.

Dr. Richard D. Siegel is a Principal Engineer at Walden and has had extensive program management experience on other projects including EPA projects associated with development and evaluation of a series of control plans for fuel burning sources for meeting the EPA secondary standards for SO_2 and particulates in the Metropolitan Boston AQCR, preparation of Vermont and Illinois air quality data in SAROAD format, development of the Massachusetts Air Quality Maintenance Plan, and evaluation of the impact of the energy shortage on air quality. He was also principal investigator of our evaluation of the potential impact on air quality of various alternative traffic schemes in the North Terminal area of Boston and a number of other urban renewal complex source environmental impact assessments. Dr. Siegel was also responsible for a recently completed comprehensive

air quality assurance study for EPA in EPA Region III. Dr. Siegel received his B.S. and M.S. degrees in Chemical Engineering from Tufts University in 1964 and 1966, respectively. He received his Ph.D. in Chemical Engineering from Lehigh University in 1969. Prior to joining Walden, he participated in several programs related to the nature and control of aircraft engine exhaust emissions which led to the EPA promulgation of emission standards for turbine engine aircraft. He has also contributed to studies of NO_x formation in turbine and diesel engine systems and in the development of alternative power plants for automotive propulsive power. His present responsibilities include preparation of environmental impact statements, emission inventories, and control strategy evaluations.

Mr. Khee M. Chng is a Senior Engineer at Walden with extensive training and experience in systems studies. Mr. Chng has been a principal contributor in a number of EPA sponsored studies relating to the development of methodologies for reviewing and updating emissions inventories and air quality data compiled by state and local agencies and converting these various data bases into formats which are compatible with NEDS and SAROAD. His more recent activities included the development of a set of computer programs for automotive emissions calculations and atmospheric diffusion simulation, which were subsequently applied to evaluate transportation control strategies for Boston, Seattle and Salt Lake City. For a Cambridge-based electric utility, Mr. Chng has developed and installed a software package for routine processing of both SO_2 and wind frequency data. He is currently managing a project to evolve

a set of computer programs for allocating local and gas consumption on a county basis. Similar to its predecessor, the liquid fuel analog, this project will also require follow-up consultation to ensure JCL and data format compatibility. Mr. Chng is presently responsible for all systems analysis studies and software development work at Walden.

Mr. Kenneth Wiltsee is an Environmental Engineer at Walden with extensive experience in ambient monitoring, including site selection studies, instrument specification, on-site field operation and maintenance, and analysis and interpretation of aerometric data. Mr. Wiltsee has had extensive experience in designing monitoring networks, both for compliance monitoring and as part of a closed loop system in episode alert and control. These studies have included use of regional and local climatology to develop cost-effectiveness matrices for locating monitors. Mr. Wiltsee has also had considerable experience in modeling effluent dispersion in complex valley terrain. He has prepared environmental impact statements for nuclear and fossil fuel power plants, fossil fuel gasification facilities, and compressor stations. He is familiar with all aspects of systems analysis and has developed many software packages with particular emphasis on system development for processing and analyzing meteorological and air quality data. Mr. Wiltsee is currently involved in a study sponsored by the Environmental Protection Agency (EPA) to evaluate the impact of the energy crisis on air quality using Metropolitan Boston as a case study area.

Mr. Joseph Myers is also an Environmental Engineer at Walden. His expertise includes broad experience in the processing and analysis of aerometric data. He has designed, developed and implemented computer programs for analysis of meteorological and air quality data related to such projects as nuclear power

plant site selection and environmental impact studies, pollution forecasts, and operational curtailment design for real-time closed loop SO_2 monitoring systems. He has also developed a number of computer programs for diffusion estimates of multiple point and area source configurations. Mr. Myers is currently involved in an EPA sponsored project to develop methodology to upgrade the National Emissions Data System (NEDS) Area Source Data Bank.

Mr. Paul Morgenstern is a Principal Scientist and Director of the Environmental Systems Studies Group at Walden. He received an M.S. in Meteorology from M.I.T. in 1955 and has additional graduate study in applied mathematics and statistics. He has been project manager on the majority of our EPA task order assignments and basic ordering agreement contracts on assistance to Federal and state control agencies. He has been principal investigator of all EPA assignments in emission inventory, including our recent update of the NEDS inventory for Maine, New Hampshire, Vermont and Delaware, and of several projects involving diffusion modeling, the preparation of implementation plans, and the evaluation of alternative control strategies to meet air quality standards. He is current project manager of a project for EPA to evaluate, through diffusion modeling, the impact of compliance extensions for power plants to relieve the aggregate low-sulfur coal deficit projected for 1975. He is also responsible for a NASA project involving statistical analysis of rocket-sounding upper atmosphere density data.

E. RESEARCH AND DEVELOPMENT FACILITIES AND EQUIPMENT

The offices, laboratories and production facilities of Abcor, Inc. are contained in three buildings in Cambridge, Massachusetts within each reach of M.I.T., Harvard, and other Boston area universities. Within a total floor space of about 100,000

ft^2, about one-third is devoted to offices and well-equipped laboratories, with the remainder used for equipment production and assembly areas, pilot plants, and a complete machine and model shop.

The Walden Research Division has offices and laboratories in each of these buildings, with a total floor space of about 10,000 ft^2. Of this area, approximately 3,000 ft^2 is for laboratory facilities.

Walden's two analytical laboratories ($\tilde{}$1,000 ft^2) are used extensively for assaying air samples in support of Walden contract programs and other corporate activities. The laboratories were designed for maximum flexibility to accomodate research in many different areas of particulates and gases, including gas velocity and temperature measuring equipment, high volume and passive air samplers, microscopy equipment for sizing and conducting particulate samples, and a chemical apparatus to permit both analysis and research. We continue to add, through a reasonable capital investment program, to our laboratory capabilities.

More specifically, we have source sampling equipment conforming to specifications established by the American Society of Testing and Materials (ASTM), American Society of Mechanical Engineers (ASME), Western Precipitator (WP Bulletin 50), Industrial Gas Cleaning Institute (IGCI), Federal Agencies (PHS, EPA, APCO), and others. We employ sampling apparatus of special and of proprietary design and also a commercially-available system (R.A.C. Staksamplr) and maintain a spirometer for accurate calibration of flow metering devices. Ambient sampling equipment includes Beckman NDIR Carbon Monoxide Analyzers, AISI Tape Sampler, Hi Vol samplers, Climet meteorological sensors for wind speed and direction, sulfation and fall-out sampling stations, bubblers and associated air moving and metering equipment. We have acquired and utilized a variety of continuous monitoring equipment for special, one-time programs.

Our laboratory is equipped with analytic instrumentation to support essentially all standard procedures for ambient and source testing. This instrumentation includes a Bausch and Lomb Spectronic 20 Colorimeter, and an Orion Model 701 Digital pH Meter equipped with chloride, fluoride and nitrate electrodes. For more detailed analysis and for research on methods development and emissions characterization, Walden has a Perkin Elmer Model 900 Research Gas Chromatograph. Special procedures for combustion effluent analysis have been developed for that chromatograph, which is equipped with both thermal conductivity detectors for general work, and also flame ionization detectors for hydrocarbon analyses. Our analytic laboratory is also equipped with a Heath/Schlumberger Model UV/VIS spectrophotometer and atomic absorption instrument. This instrument provides a general capability to perform trace metal analyses.

Walden has constructed, at its own expense, a medium-scale (400,000 Btu/hr) pilot combustion plant and associated research facilities. The present burner is a combination gas-distillate oil unit. The system can be adapted to residual, distillate, and pulverized coal-gas fuel. The pilot plant is designed to permit simultaneous testing in hot (approximately 800°F) and cold (approximately 350°F) test sections allowing operations above and below both water and acid dewpoint for various compositions. Realistic test conditions for a wide variety of effluent compositions can be simulated by the addition of dopants. The pilot plant, in addition to serving as a realistic test bed for methods development, can serve as a basis for combustion research including flame studies, emission measurement, fuel additives, effects, etc.

Walden's instrument development laboratory is equipped and staffed to design, breadboard, package and test a wide variety of devices. Test equipment includes oscilloscopes, signal sources, voltmeters, pressure flowmeters, etc.

Our data processing work is conducted at separate facilities. For batch processing of large data file jobs, we maintain open purchase order agreements with several commercial service bureaus. One of these is with Systematic Data Processing Services, Inc. for access to IBM 370/155 facilities. Processing tasks requiring more powerful facilities are scheduled with Wang Computer Services, Division of Wang Laboratories, Inc., which offers an IBM System 370/158. We maintain an in-house file of System Reference Library and Application Program documentation for these various data processing systems. Several computer programs of particular applicability to air pollution studies are maintained in an operational state. These include:

(1) APRAC-1A urban diffusion model
(2) Several highway line source models
(3) Motor vehicle emission estimation model (VEHEMI)
(4) Multiple-source diffusion model (updated AQDM)
(5) Single-stack trapping and fumigation diffusion models
(6) Emissions inventory preparation and management programs (IPP, NEDS formats)
(7) Graphical display programs for emission inventories and diffusion modeling.

Quick access is available to the libraries of Harvard and M.I.T. and the extensive technical library of the Air Force Cambridge Laboratory in Bedford, Massachusetts. We possess an in-house library of air pollution and aerosol literature and are experimenting with a proprietary textual computer storage and retrieval system for managing these information files.

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PETER H. GULDBERG - Atmospheric Scientist

SPECIALTIES: Diffusion modeling, computer systems design, applied mathematics, fluid dynamics, atmospheric physics, statistics.

EXPERIENCE

Walden Research Division of Abcor, Inc., Cambridge, Mass., 1974 - Atmospheric Scientist. Preparation of environmental impact statements and diffusion modeling research. Data processing and programming support for modeling activities. Responsibilities include active participation in projects, preparation of technical reports and program management assistance.

Department of Atmospheric and Oceanic Science, The University of Michigan, Ann Arbor, Michigan, 1973 - 1974. Research assistant in a theoretical study of the mathematical predictability of the atmosphere.

Department of Meteorology, Massachusetts Institute of Technology, Cambridge, Mass., 1973. Developed a fast fourier-spectral transform system for the atmospheric dynamics model used in the study of the effects of SST stratospheric emissions on atmospheric ozone. Project was part of the Climatic Impact Assessment Program of the U. S. Department of Transportation.

Center for Space Research, Massachusetts Institute of Technology, Cambridge, Mass., 1972 - 1973. Programming and data analysis for OSO-7 X-Ray satellite experiment package.

Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Mass., 1971-1972 (part time). Implementation of computerized financial control system for the school of management.

Project MAC, Massachusetts Institute of Technology, Cambridge, Mass., 1970-1971. Systems design of data bank management systems, MACAIMS.

Thetford Corporation, Ann Arbor, Michigan, 1969-1970. Business applications programming.

PHG - 2

EDUCATION

B.S. Mathematics, Massachusetts Institute of Technology, 1973
M.S. Atmospheric Science, The University of Michigan, 1974.

PROFESSIONAL SOCIETIES

American Meteorological Society

HONORS

University of Michigan Research Assistantship in Atmospheric Science.

PUBLICATIONS

Guldberg, P.H., "A Comparison Study of Plume Rise Formulae Applied To Tall Stack Data", (to be published).

Siegel, R.D., Hebert, R.P. and Guldberg, P.H. "Air Quality Monitoring and Analysis Program for the J. F. Kennedy Memorial Library Environmental Impact statement", in preparation.

Guldberg, P.H. and Siegel, R.D., "Air Quality Impact Modeling Program for the J. F. Kennedy Memorial Library Environmental Impact Statement", in preparation.

Siegel, R.D., Guldberg, P.H. and Hebert, R.P., "Air Pollution Impact of J. F. Kennedy Memorial Library", prepared for C.E. Maguire, Inc., Waltham, Mass. (1974).

DR. RICHARD D. SIEGEL - Principal Engineer

SPECIALTIES: Air pollution technology, impact studies and statement preparation, control strategy evaluations, ambient surveys, gas turbine emissions, instrumentation and sampling, combustion, kinetics, heat transfer, mathematical modeling, membrane transport, program planning and management.

EXPERIENCE

Walden Research Division of Abcor, Inc., Cambridge, Mass., 1972 - Principal Engineer. Preparation of environmental impact statements, emission inventories and control strategy evaluations. Dispersion modeling, ambient air quality measurement programs, instrument development. Mobile source emission control. Responsibilities include project management, active participation in projects and preparation of technical reports and proposals.

Northern Research Corporation, Cambridge, Mass., 1969-1972. Senior Engineer. Conducted theoretical and experimental research and development investigations of air pollution control, combustion, and heat transfer problems. Modeled NO_x production in aircraft gas turbine combustors. Investigated nature of aircraft engine exhaust emissions, control strategies, and emission impact. Evaluated emissions measurement instrumentation, sampling and test procedures for aircraft engines. Managed engine test cell emissions abatement program. Developed design and optimization procedure for wet gas condensation in compact heat exchangers. Supersonic combustion studies. Consultant to private industry. Technical and cost proposal preparation. Program planning and management.

Northeastern University, Boston, Mass., 1970. Lecturer in Chemical Engineering. Taught Chemical Engineering Thermodynamics in addition to full-time responsibilities at NREC.

Cabot Corporation, Billerica, Mass., Summer 1966. Chemical Engineer. Conducted research and development studies leading to a unique direct flame process for TiO_2 production.

Tufts University, Medford, Mass., 1964-1966. Graduate Teaching Assistant in Chemical Engineering. Supervised and instructed students in both undergraduate and graduate Chemical Engineering courses.

EXPERIENCE (continued)

Tufts University, Medford, Mass., Summer 1964. Computation Centre Assistant. Supervised centre operations and assisted Director in preparation of textbook on numerical methods and computers.

EDUCATION

B.S. Chemical Engineering, Tufts University, 1964
M.S. Chemical Engineering, Tufts University, 1966
Ph.D. Chemical Engineering, Lehigh University, 1969

PROFESSIONAL SOCIETIES

American Institute of Chemical Engineers: Second Vice Chairman (1973), First Vice Chairman (1974), Chairman (1975), Environmental Division.
Ichthyologists (Boston Section, AIChE): Founder and Chairman of Boston Area Pollution Solution Group
American Chemical Society
Air Pollution Control Association
American Society of Mechanical Engineers
New York Academy of Science
American Association for the Advancement of Science

HONORS

Who's Who In the East, Sigma Xi, Tufts University Teaching Assistantship in Chemical Engineering, Texaco Fellow, U.S. Steel Fellow, Listed in International Scholars Directory and in American Men and Women of Science, Who's Who in Massachusetts - 1974.

PATENTS

Coughlin, R.W. and Siegel, R.D., "Semipermeable Membrane of Enhanced Properties", U.S. Patent 3,720,321 (1973), Japanese Patent Pending (1971) No. 12157/1971, Italian Patent 922,515 (1972), Swedish Patent Pending (1971), No. 3009/71, Netherlands Patent Pending (1971), No. 7103143, Canadian Patent Pending (1971), No. 106,924, Great Britian Patent 1,341,874 (1973), West German Patent Pending (1971) No. P2111773.7.

Over thirty journal articles, reports and presentations. Also co-editor of AIChE publication and columnist in Environmental Division Newsletter. Chairman or Vice Chairman of several AIChE Symposia.

RICHARD D. SIEGEL

PUBLICATIONS

Siegel, R. D. and Coughlin, R. W., "Increasing Permeability of Polymer Membranes by Irradiation in the Fully Swollen State," Nature 226, 938-940 (June 6, 1970).

Siegel, R. D. and Coughlin, R. W., "Enhancing the Permeation Characteristics of Polyethylene by Membrane Irradiation in the Fully Swollen State," presented at the Third Joint Meeting of the AIChE with the PRIChE, San Juan, Puerto Rico (May 16 - 20, 1970).

Siegel, R. D. and Coughlin, R. W., "Enhancing the Permeation Characteristics of Polyethylene by Membrane Irradiation in the Fully Swollen State," Journal of Applied Polymer Science, 14 (10), 2431-2439 (1970).

Siegel, R. D. and Coughlin, R. W., "Errors in Diffusivity as Deduced from Permeation Experiments Using the Time-Lag Technique," presented at the AIChE 68th National Meeting, Houston, Texas (February 28 - March 4, 1971).

Siegel, R. D. and Coughlin, R. W., "Errors in Diffusivity as Deduced from Permeation Experiments with the Time-Lag Technique," Recent Advances in Separation Techniques, AIChE Symposium Series, 68 (120), 58 - 60, (1972).

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Siegel, R. D. and Van Wormer, K. A., Jr., "The Effect of Solid Particles on Nucleate Boiling from a Horizontal Plate" (in preparation).

Demetri, E. P. and Siegel, R. D., "Development of a Computerized Analytical Technique for the Design and Optimization of Wet Gas Heat Exchangers," vols 1, 2, and 3, Northern Research and Engineering Corporation, Report No. 1156-1, 2, and 3, Prepared for the NASA Manned Spacecraft Center, Cambridge, Massachusetts (1970).

Fletcher, R. S., Siegel, R. D., and Bastress, E. K., "The Control of Oxides of Nitrogen Emissions from Aircraft Gas Turbine Engines," Northern Research and Engineering Corporation, Report Nos. 1162-1, 2, and 3, Prepared for the Federal Aviation Administration, Cambridge, Massachusetts (1971) (FAA Report Nos. FAA-RD-71-111-1, 2, and 3; also AD741505, AD741506, and AD741570).

RICHARD D. SIEGEL

PUBLICATIONS (continued)

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Bastress, E. K., Baker, R. C., Robertson, C. F., Siegel, R. D., and Smith, G. E., "Assessment of Aircraft Emission Control Technology," Northern Research and Engineering Corporation, Report No. 1168-1, Prepared for the Office of Air Programs of the Environmental Protection Agency, Cambridge, Mass., PB204878 (1971).

Siegel, R. D., "A Review of Instrumentation, Test and Sampling Procedures for Measurement of Aircraft Engine Pollutant Emissions," JAPCA, 22 (11), 845-853 (1972).

Fletcher, R. S., Heywood, J. B., and Siegel, R. D., "A Model for Nitric Oxide Emissions from Aircraft Gas Turbine Engines" (To be submitted for review to Combustion Science and Technology).

Siegel, R. D., "The Awakening of the Ichthyologists or the Establishment of the Boston, Massachusetts Section's Pollution Solution Group," Presented at the AIChE 65th Annual Meeting, New York, N.Y. (November 26-30, 1972).

Siegel, R. D., "The Awakening of the Ichthyologists or the Establishment of the Boston, Massachusetts Section's Pollution Solution Group," Water-1972, AIChE Symposium Series, 69 (129), 481-3 (1973).

Coughlin, R.W., Siegel, R.D., and Rai, C., co-editors, Recent Advances In Air Pollution Control, AIChE Symposium Series 70 (137) (1974).

Siegel, R. D., "What You Always Wanted to Know About the Environment But Were Afraid to Ask," AIChE Symposium Series, Water-1973, 70 (136), 788-797 (1974).

Siegel, R. D., Ehrenfeld, J. R., and Morgenstern, P., "Strategies for Reduction of Particulate Emissions in Urban Areas," presented at the AIAA Third Urban Technology Conference, Boston, Mass. (Sept. 26-28, 1973).

RICHARD D. SIEGEL

PUBLICATIONS (continued)

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Siegel, R.D., Morgenstern, P., and Hagg, K., "Control Particulate Emissions from Stationary Fuel Burning Sources in the Core Area of the Metropolitan Boston Air Quality Control Region", to be published.

Siegel, R.D., Porter, J.H., and McCoy, J.F., "Procedures for Concentration and Velocity Measurement for Stratified Flow in Large Ducts", presented at the AIChE 78th National Meeting, Salt Lake City, Utah, (August, 1974).

Siegel, R.D., co-editor, *Air-1973*, AIChE Symposium Series Volume (to be published).

Swartz, P., Chng, K.M., and Siegel, R.D., "Computer Programs for the Conversion of Illinois State Air Quality Data to the Saroad Format", Prepared for the Environmental Protection Agency and the State of Illinois, Cambridge, Mass. (1973).

Siegel, R.D., Morgenstern, P., and Chng, K.M., "Air Pollution Impact of North Terminal Project, Boston, Massachusetts", prepared for Wallace, Floyd & Ellenzweig, Inc., Cambridge, Mass. (1973).

Siegel, R.D., "Evaluation of Strategies for the Reduction of Particulate Emissions in the Metropolitan Boston Air Pollution District", presented at the Joint Meeting of the New England Environmental Health Societies, Braintree, Mass. (January, 1974).

RICHARD D. SIEGEL

PUBLICATIONS (continued)

Zakak, A., Siegel, R.D., McCoy. J., et al., "Procedures for Measurements In Stratified Gases", prepared for the Environmental Protection Agency, Cambridge, Mass. (1974).

Morgenstern, L., Shah, M.C., Siegel, R.D., "SAROAD Air Quality Data Review (Regions I, II, III)", prepared for the Environmental Protection Agency, Cambridge, Mass. (1974).

Siegel, R.D., Hebert, R.P. and Guldberg, P.H. "Air Quality Monitoring and Analysis Program for the J. F. Kennedy Memorial Library Environmental Impact statement", in preparation.

Guldberg, P.H. and Siegel, R.D., "Air Quality Impact Modeling Program for the J. F. Kennedy Memorial Library Environmental Impact Statement", in preparation.

Siegel, R.D., Guldberg, P.H. and Hebert, R.P., "Air Pollution Impact of J. F. Kennedy Memorial Library", prepared for C.E. Maguire, Inc., Waltham, Mass. (1974).

Siegel, R.D., Morgenstern, P., and Ehrenfeld, J.R., "Particulate Emission Factors for Fuel Burning Sources", in preparation.

Siegel, R.D., Guldberg, P.H. and D'Agostino, A., "The Impact of the Energy Shortage on Air Quality in the Metropolitian Boston AQCR: Part I - Air Quality Analysis", In Preparation.

Siegel, R.D., Guldberg, P.H. and Wiltsee, K. W., Jr., "The Impact of the Energy Shortage on Air Quality in the Metropolitan Boston AQCR: Part II - Modeling Analysis", In Preparation.

KHEE M. CHNG - Senior Engineer

SPECIALTIES: Airport air quality analysis, Atmospheric diffusion modeling, environmental impact statement preparation, transportation control strategy evaluation, systems analysis.

EXPERIENCE

Walden Research Division of Abcor, Inc., Cambridge, Mass., 1973 - Senior Engineer. Preparation of EIS's for airport, highway, and complex sources. Development of fuel allocation methodologies. Evaluation of control strategy for transportation and stationary sources. Atmospheric diffusion modeling and air quality analysis. Development and application of combustion and emission system models. Responsible for all computer program development and data management activities associated with BOA task order projects.

GCA Technology Division, Bedford, Mass., 1972 - 1973. Senior Scientist. Responsible for all data processing in the Air Pollution Control Group. Development of several computer programs to estimate emission densities for roll back analysis and evaluate impact on air quality due to salt spray from condensers and from waste oil combustion. Statistical analysis of measured SO_2 and wind data, evaluation of transportation control strategies. Liaison with local utility company for continuing surveillance on SO_2 monitoring program.

Northern Research and Engineering Corporation, Cambridge, Mass., 1969 - 1972. Engineer, Technology Applications Group. Major participant in a series of studies, sponsored by both EPA and FAA on impact on air quality due to airport operations. Responsible for development of models on airport activity, aircraft and vehicular emission sources, emission factors as function of LTO cycle. Atmospheric diffusion and impact on airport environs. Other activities include evaluation of economic and operational feasibility of using ground operation procedures to minimize impact on air quality, development of computer programs to determine nitric oxide formation and indicated performance of both direct- as well as indirect-injection diesel engines, and evaluation of both technical and economic feasibility of integrating diagnostic centers in state motor vehicle inspection programs.

Massachusetts Institute of Technology, Cambridge, Mass., 1965 - 1967. Staff member of the Division of Sponsored Research. Development of polarographic techniques for determining trace metals in aqueous samples. Collection and analysis of aerosols in the atmosphere. Other areas include coulometric titration of halides, and development of stills for high purity water with extremely low free metal and associated complexes.

EDUCATION

B.S. Earth Sciences, Massachusetts Institute of Technology, 1965
Continuing graduate work in the physical sciences at MIT, 1965 and 1966.

PROFESSIONAL SOCIETIES

Air Pollution Control Association

PUBLICATIONS

About a dozen major technical reports and presentations to professional societies.

KHEE M. CHNG

PUBLICATIONS

Chng, K.M., "Modeling Study of Impact on Ambient SO_2 Levels from Changes In Stack Height, Operating Loads, and Fuel Switching at Petersburg Generating Station", Prepared for Gibbs & Hill, Inc., New York, N. Y., (August, 1974).

Chng, K.M., "The Potential Impact Upon Air Quality Due to Aircraft and Automotive Activities in the Vicinity of the U. S. Mail Facility Located Next to Syracuse Airport", Prepared for Bolt, Beranek and Newman, Inc., Waltham, Mass. (July, 1974).

Chng, K.M., "Air Pollution Impact of Proposed I-391 Construction Connecting Holyoke and Chicopee, Massachusetts", Prepared for Sverdrup & Parcel and Associates, Inc., Boston, Mass. (May, 1974).

Morgenstern, P., Morgenstern, L.N., Chng, K.M., Barrett, D.H., and Mears, C.E., "Modeling Analysis of Power Plants for Compliance Extensions in 51 Air Quality Control Regions", (to be published).

Goldish, J.C., Trowt, F.D., Ehrenfeld, J.R., Chng, K.M., and Stockdale, R., "Development of a Methodology to Allocate Liquid Fossil Fuel Consumption by County", Prepared for Environmental Protection Agency, Office of Air Programs, Research Triangle Park, N.C., under Contract No. 68-02-1067 (March 1974).

Swartz, P., Chng, K.M., and Siegel, R.D., "Computer Programs for the Conversion of Illinois State Air Quality Data to the SAROAD Format", Prepared for Environmental Protection Agency, Region V, Air Surveillance Branch, Chicago, Illinois, under Contract No. 68-02-0049 (December 1973).

Chng, K.M., and Mayfarth, H., "User's Manual for SO_2 Data Analysis Programs", GCA Technology Division, Bedford, Massachusetts, Prepared for New England Gas and Electric Association, Cambridge, Massachusetts, under Contract No. 12157 (January 1973).

Chng, K.M., "User's Manual for the Motor Vehicle Emissions Program", GCA Technology Division, Bedford, Massachusetts, Prepared for Environmental Protection Agency under multiple task order contracts (November 1972).

KHEE M. CHNG

PUBLICATIONS (continued)

Platt, M., Chng, K.M., and Bastress, E.K., "Assessing the Impact of Aircraft Emissions Upon Air Quality" (APCA Paper No. 72-166), Presented at the 65th Annual Meeting of the Air Pollution Control Association, Miami Beach, Florida (June 18 - 22, 1972).

Platt, M., Baker, R.C., Bastress, E.K., Chng, K.M., and Siegel, R.D., "The Potential Impact of Aircraft Emissions Upon Air Quality", Northern Research and Engineering Corporation, Cambridge, Mass., Prepared for Environmental Protection Agency, Durham, North Carolina, under Contract No. 68-02-0085 (December 1971).

Platt, M., Chng, K.M., and Siegel, R.D., "Computer Program for the Air Quality Analysis of Airports", Northern Research and Engineering Corporation, Cambridge, Mass., Prepared for Environmental Protection Agency, Durham, North Carolina, under Contract No. 68-02-0085 (August 1971).

Bastress, E.K., Chng, K.M., and Dix, D.M., "Models of Combustion and Nitrogen Oxide Formation in Direct and Indirect Injection Compression-Ignition Engines" (SAE Paper No. 719053), Presented at the 1971 Intersociety Energy Conversion Engineering Conference, Boston, Massachusetts (August 4, 1971).

Chng, K.M., "Computer Programs for Predicting Indicated Performance and NO_x Emission Rates for Diesel Engines", Northern Research and Engineering Corporation, Cambridge, Mass., Prepared for Environmental Protection Agency, Office of Air Programs, under Contract No. EHS 70-116 (June 8, 1971).

Bastress, E.K., Chng, K.M., Dix, D.M., and Murad, R.J., "Control of Nitrogen Oxide Emissions from Diesel Engines: A Theoretical Analysis", Northern Research and Engineering Corporation, Cambridge, Mass., Prepared for Environmental Protection Agency, Office of Air Programs, under Contract No. EHS 70-116 (June 8, 1971).

Fletcher, R.S., Chng, K.M., Heywood, and Bastress, E.K., "Model of Combustion and NO Formation in Direct and Indirect C.I. Engines", Paper presented at Central States Section Meeting, The Combustion Institute, Ann Arbor, Michigan (March 23 - 24, 1971).

KHEE M. CHNG

PUBLICATIONS (continued)

Blatt, T.A., Chng, K.M., and Goodman, H.B., "Diagnostic Centers", Northern Research and Engineering Corporation, Cambridge, Mass., Prepared for the U.S. Department of Transportation, National Highway Safety Bureau, Washington, D.C., Contract No. FH-11-7287 (July 1970).

PAUL MORGENSTERN - Principal Scientist

SPECIALTIES: Environmental impact studies, meteorological surveys, emission inventories, diffusion modeling, statistical and numerical analysis, data processing.

EXPERIENCE

Walden Research Division of Abcor, Inc., Cambridge, Mass., 1968- Manager, Environmental Systems. Responsible for direction of control agency technical assistance programs and industrial environmental consulting services. Projects include comprehensive statewide air pollutant emission inventories for Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and Delaware; evaluation of control regulations on air quality levels for Maine, Massachusetts, and Rhode Island; investigation of air quality impact from compliance extensions for power plants in 51 Air Quality Control Regions; development of applications for control agency information storage and retrieval systems; research on model atmospheres for the stratosphere and mesosphere for earth resource applications.

GCA Technology Division, Bedford, Mass., 1963-1968. Staff Scientist. Design and analysis of atmospheric pollution measurement program for greater Boston area and for large electrical generation stations. Development of diffusion prediction models and validation by field tests. Determination of particle size distributions of aerosols by numerical methods from mass decay measurements. Power spectra of turbulence in atmospheric boundary layer. Systems studies of meteorological data collection and processing networks.

Radio Corporation of America, Burlington, Mass., 1957-1963. Engineering Scientist. Responsible for operations research and systems analysis studies for Air Force and NASA programs, including SAC 480L and SATURN C-1. Design of aerial radiological monitoring system and radiological study for New York City.

U.S. Air Force, Kadena Air Force Base, Okinawa, 1955-1957. Weather Officer.

Massachusetts Institute of Technology, Lincoln Laboratory, 1955. Staff Member. Meteorological research on radar precipitation interference predictions.

EDUCATION

B.S., Meteorology, St. Louis University (cum laude), 1953.
S.M., Meteorology, MIT, 1955.
Continuing graduate study leading to Ph.D. at MIT.

PROFESSIONAL SOCIETIES

American Meteorological Society
Operations Research Society of America
Air Pollution Control Association

PUBLICATIONS

Over thirty major technical reports and presentations to professional societies.

PAUL MORGENSTERN

PUBLICATIONS

Morgenstern, P., "The Synoptic Climatology of Weather Radar Pictures," Studies in Radar Climatology, Res. Rpt. No. 25, Part I, Weather Radar Research, MIT, Cambridge, Massachusetts (1956).

Morgenstern, P., "Simulation of the Dynamic Radar Cross Section from Orbital Bodies of Simple Shape," RCA Technical Report under Contract No. AF3-(602)-2359, Burlington, Massachusetts (1962).

Morgenstern, P., "Mayor's Radiological Committee Study Report," RCA Technical Report for the Office of Civil Defense, City of New York (1962).

Cramer, H. E., DeSanto, G. M., Dumbauld, R. K., Morgenstern, P., Swanson, R. N., "Meteorological Prediction Techniques and Data System," GCA Final Report under Contract No. DA-42-007-CM1-552, U.S. Army Dugway Proving Ground, Dugway, Utah (1964).

Morgenstern, P., "Interlevel Wind Correlations in the Upper Atmosphere," Ionospheric Wind and Diffusion Measurements, (ed. J. Bedinger), GCA Addendum to Project Officer's Report, Project 9-1b under Contract No. AF19(628)-399, AFCRL, Bedford, Massachusetts (1964).

Morgenstern, P. and Newman, E., "Spectral Analysis of Elevation Angle Wind Fluctuations at Dugway Proving Ground," GCA Technical Report under Contract No. DA-42-007-AMC-120(R), U.S. Army Dugway Proving Ground, Dugway, Utah (1965).

Dennis, R., Cramer, H. E., and Morgenstern, P., "Report on Advanced Planning for the Metropolitan Air Pollution Control District Survey," GCA Final Report under Contract No. 4227-00-00, Department of Public Health, Commonwealth of Massachusetts, Boston, Massachusetts (1965).

Cramer, H. E., DeSanto, G. M., Dumbauld, R. K., Greene, B. R., Morgenstern, P., and Swanson, R. N., "CB Field Test Prediction Trials," GCA Final Report under Contract No. DA-42-007-AMC-36(R), U.S. Army Dugway Proving Ground, Dugway, Utah (June 1965).

Rosenblum, E. and Morgenstern, P., "Feasibility and Exploratory Development of Procedures and Instrumentation for the Field Evaluation of Military Obscuration Agents," GCA Fourth Quarterly Progress Report under Contract No. DA-18-035-AMC-706(A), U.S. Army Edgewood Arsenal, Maryland (August 1966).

PAUL MORGENSTERN

PUBLICATIONS (continued)

Morgenstern, P., "Probability Estimates of Cloud Free Line-of-Light," GCA Internal Memorandum SRL-66-PM-89 under Contract No. AF40(600)-1158, Arnold Air Force Station, Tenn. (July 1966).

Cramer, H. E., DeSanto, G. M., Greene, B. R., and Morgenstern, P., "Procedures for Processing Dosage and Meteorological Measurements," GCA Technical Report under Contract No. DA-42-007-AMC-120(R), U.S. Army Dugway Proving Ground, Dugway, Utah (February 1967).

Minzner, R. A., Morgenstern, P., and Mello, S. M., "Tabulations of Atmospheric Density, Temperature and Pressure from 437 Rocket and Optical-Probe Soundings During the Period 1947 to Early 1965," GCA Technical Report under Contracts NASw-1463 and NASw-1225, NASA Hq., Washington (May 1967).

Dennis, R., Doyle, A. W., Gordon, D., Hommel, C. O., Morgenstern, P., and Sacco, A. M., "Aerosol Dissemination Assessment," GCA Fifth Quarterly Progress Report under Contract No. DA-18-035-AMC-376(A), U.S. Army Edgewood Arsenal, Maryland (October 1967).

Morgenstern, P., "A Technique for Particle Sizing by Means of Sedimentation Analysis," Presented at the 29th Annual Meeting of the American Industrial Hygiene Association (April 1968).

Kneizys, F., Morgenstern, P., and Schuler, C., "Exploratory Development of a Contrast Photometer and Its Methods of Use of Field Evaluation of Military Obscuration Systems," GCA Final Report under Contract No. DAAA-15-67-C-0333, U.S. Army Edgewood Arsenal, Maryland (June 1968).

Minzner, R. A. and Morgenstern, P., "Structure and Variability of Earth's Atmosphere," GCA Final Report under Contract No. NASw-1463, NASA Hq., Washington, D.C. (November 1968).

Minzner, R. A. and Morgenstern, P., "Range and Structure of Ambient Density from 30 to 120 km Altitude," GCA Final Report under Contract No. NAS8-20098, NASA Marshall Space Flight Center, Huntsville, Alabama (October 1968).

Morgenstern, P., Doyle, A. W., and Ehrenfeld, J. R., "Analysis of Terrain Denial Test Data," Walden Research Corporation Final Report under Contract No. DAAA15-69-C-0436, U.S. Army Edgewood Arsenal, Maryland (May 1969).

PAUL MORGENSTERN

PUBLICATIONS (continued)

Berger, A. W., Driscoll, J. N., and Morgenstern, P., "Review and Statistical Analysis of Stack Sampling Procedures for the Sulfur and Nitrogen Oxides in Fossil Fuel Combustion," Paper No. 70-33 Presented at 63rd Annual APCA Meeting, St. Louis, Mo. (June 1970).

Morgenstern, P., Goldish, J. C., and Davis, R. L., "Air Pollution Emission Inventory for the Metropolitan (Boston) Air Pollution Control District," Walden Research Corporation Final Report prepared for Massachusetts Bureau of Air Use Management, Boston, Mass. (June 1970).

Morgenstern, P. and Orner, R. G., "Multivariate Regression Analysis of Atmospheric Density in the Region 30 to 110 km," Walden Research Corporation Final Report under Contract No. NAS12-2125, prepared for NASA/Electronics Research Center, Cambridge, Mass. (Oct. 1970).

Morgenstern, P., Goldish, J. C., and Carr, K. A. P., "Supplement to the Air Pollutant Emission Inventory for the Metropolitan Boston Air Pollution Control District (Summary Report)," Walden Research Corporation Final Report under Contract No. CPA 70-165, prepared for Massachusetts Bureau of Air Use Management, Boston, Mass. (Nov. 1970).

Minzner, R. A. and Morgenstern, P., "Analysis of Several Relations Among Atmospheric Statistics," NASA TR R-365, NASA/Electronics Research Center, Cambridge, Mass. (March 1971).

Morgenstern, P., Goldish, J. C., and Orner, R. G., "Air Pollutant Emission Inventory for the Metropolitan Providence Interstate Air Quality Control Region," Walden Research Corporation Final Report under Contract No. CPA 70-165, prepared for EPA, APCO, Raleigh, N.C. (Jan. 1971).

Morgenstern, P., Goldish, J. C., and Orner, R. G., "Air Pollutant Emission Inventory for the State of New Hampshire," Walden Research Corporation Summary Report under Contract No. 68-02-0049 prepared for EPA, OAP, Raleigh, N.C. (Jan. 1972).

Morgenstern, P., Goldish, J. C., and Orner, R. G., "Control Plan for the State of Rhode Island (Technical Studies)," Walden Research Corporation Final Report under Contract No. 68-02-0049 prepared for EPA, OAP, Raleigh, N.C. (Jan. 1972).

PAUL MORGENSTERN

PUBLICATIONS (continued)

Morgenstern, P., Goldish, J. C., Orner, R. G., Parks, T. R., and Carrier, E. B., "Air Pollutant Emission Inventory for the Commonwealth of Massachusetts," Walden Research Corporation Summary Report under Contract No. 68-02-0049 prepared for EPA, OAP, Raleigh, N.C. (June 1972).

"Development of an Implementation Plan for the State of Maine," Walden Research Corporation Final Report under Contract No. 68-02-0049 prepared for EPA, OAP, Raleigh, N.C. (May 1972).

Morgenstern, P., Parks, T. R., and Calcagni, J., "Air Pollutant Emission Inventory for the Metropolitan Boston Air Pollution Control District (30 Municipalities)," Walden Research Corporation Summary Report under Contract No. 68-02-0049 prepared for EPA, OAP, Raleigh, N.C. (June 1972).

Morgenstern, P. and Hagg, K. A., "A System for Abatement Control Strategy Evaluation for the Metropolitan Boston Intrastate Air Quality Control Region," JAPCA, 22(10), pp. 774-778 (October 1972).

Berger, A. W., Driscoll, J. N., and Morgenstern, P., "Review and Statistical Analysis of Stack Sampling Procedures for Sulfur and Nitrogen Oxides in Fossil Fuel Combustion," AIHA (June 1973).

Siegel, R.D., Morgenstern, P., and Hagg, K., "Control of Particulate Emissions from Stationary Fuel Burning Sources in the Core Area of the Metropolitan Boston Air Quality Control Region", Paper No. 74-172 presented at 1974 AICH, Miami Beach, Florida. (May 1974).

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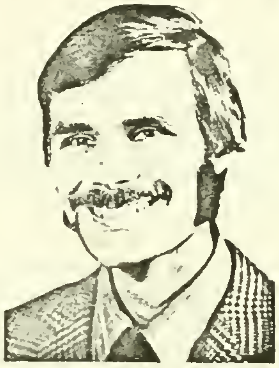
KENNETH W. WILTSEE, JR. - Environmental Engineer



SPECIALTIES - Meteorology, diffusion analysis and modeling, computer systems design, land use analysis, site selection

EXPERIENCE

Walden Research Division of Abcor, Inc., Cambridge, Mass., 1974 -. Environmental Engineer. Preparation of environmental impact statements and emissions inventories and diffusion modeling. Data processing and programming support for modeling activities. Responsibilities include execution of projects and preparation of technical reports.

Woodward-Envicon, Inc., Atlanta, Georgia, 1972 - 1974. Staff Environmentalist. Responsible for managing, developing, and executing all aspects of meteorological, demographic, and air quality programs.

Assessed the environmental impact of nuclear and fossil fuel power plants, natural gas pipelines, and fossil fuel gasification facilities; evaluated complex topography and its effects on wind flow and dispersion; investigated the impact of cooling tower induced fog at power plants.

Performed site selection and justification studies for power plants and petroleum refineries incorporating meteorological, air quality, noise and demographic data; used current methods and instrumentation in measuring ambient levels of pollutants during air quality field studies and analysis of data.

Directed and performed socio-economic, demographic, and land use studies using manual and automated techniques for assessing population characteristics in evaluating proposed pipeline, power plant, and petroleum facilities.

Designed and developed models to assess the differences in meteorological parameters between two sites, and to determine the representativeness of short-term data in comparison to areal climatology.

Developed computer programs as dictated by need for summarization or prediction of environmental factors, such as providing quality assurance of meteorological data collected in the field, predicting resultant pollutant concentrations from multi-stack sources, or forecasting the occurence and duration of restricted visibility.

Massachusetts Institute of Technology, Cambridge, Mass., 1969 - 1972. Student Research Associate. Analyzed data from Phase IV of Project Bomex (a study of tropical cyclogenesis); developed an Air Quality Display Model for the Boston Metropolitan Area; evaluated mesoscale motions of precipitation regimes.

EDUCATION

A.A. Business Management, LaSalle Extension University, Chicago, Illinois. Candidate for degree, 1975.

S.B. Physical Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1972.

National Science Foundation Grant, study in Earth and Atmosphere Sciences, Oregon State University, Corvallis, Oregon, 1967.

PROFESSIONAL SOCIETIES

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PUBLICATIONS

Environmental Impact of a Uranium Mill in the Southwest United States, Woodward-Envicon, Inc., Final Report 73634 (proprietary).

Comparison of Three Petroleum Refinery Sites in Lousiana, Woodward-Envicon, Inc., Preliminary Report 73024 (proprietary).

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Preliminary Safety Analysis Report for a Proposed Nuclear Site in Mississippi, (with D. Wolfe, et al.) Woodward-Envicon, Inc., Final Report 72001, (proprietary).

JOSEPH P. MYERS - Computer Scientist

SPECIALTIES: Computer programming, systems design and analysis, data management, documentation.

EXPERIENCE

Walden Research Division of Abcor, Inc., Cambridge, Mass., 1974 - Computer Scientist. Design, development and implementation of data processing, statistical and analytical programs in FORTRAN IV, PL/I and COBOL languages, with emphasis on computer application to environmental problems; proficient in both batch and interactive methods of remote processing. Responsible for documentation of and orientation to the use of developed programs.

Woodward Envicon, Inc., Atlanta, Ga., 1972 - 1974. Computer Scientist. Created computer program systems for processing and analyzing meteorological and air quality data. Developed computer models to calculate dispersion estimates for SO_2 and other pollutants. These models included simulation of multiple point and area source configurations for both ground level and elevated release situations, calculation of short term concentrations for specific meteorological conditions. Developed systems of programs for creation, quality assurance, maintenance and analysis of data bases for such projects as nuclear power plant site selection, real-time closed loop monitoring system operation, meteorological forecast studies, and noise surveys.

EDUCATION:

B.S. Applied Mathematics, Georgia Institute of Technology, 1970.

PUBLICATIONS

Program Documentation and Users Guide, Woodward-Envicon, Inc. (1973).

Property
BOSTON REDEVELOPMENT AUTHORITY
Library

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AIR QUALITY IMPACT MODELING PROGRAM FOR THE J.F. KENNEDY MEMORIAL LIBRARY ENVIRONMENTAL IMPACT STATEMENT

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Abstract

As part of the Environmental Impact Statement (EIS) for the proposed J.F. Kennedy Memorial Library Complex in Cambridge, Massachusetts, an air quality impact modeling program was undertaken. The objective of the impact analysis was to evaluate the maximum carbon monoxide (CO) levels which could arise as a consequence of both adverse meteorological conditions and peak roadway traffic in the project area. Detailed modeling simulations were conducted for the estimated year of completion of the Library Complex (1978) and for a future design year (1981) using the APRAC-1A urban diffusion model. Comparisons were made between the Build and No-Build situations to evaluate the differential impact of the project on community air quality. The body of information presented in this paper is directed to persons concerned with the preparation of a comprehensive air quality impact statement.

The results of the analysis show that predicted CO levels for the worst case Build option are below all applicable air quality standards, and the incremental increase in CO levels due to project generated traffic will have an insignificant effect on the attainment and maintenance of such standards. Thus, the project is judged consistent with the State Implementation Plan. Further analysis indicates an additional two year delay of Federal motor vehicle CO emission standards beyond the 1977 deadline will not significantly increase predicted CO levels. However, nonimplementation of the Boston Transportation Control Plan (BTCP) will result in violation of the Federal eight-hour CO standard in the project area in 1978 regardless of Library construction.

Introduction

The proposed location for the J.F. Kennedy Presidential Memorial Library Complex is a 12-acre site at the juncture of two major roadways, Memorial Drive and Boylston Street, one half-mile from Harvard Square in Cambridge, Massachusetts. Traffic congestion is common in the area as Memorial Drive is a principal commuter route to the urban core from suburban towns and Boylston Street is a major access road into Harvard Square. Harvard Square is a focal point of cultural and academic life in Metropolitan Boston. As required by the National Environmental Policy Act, the General Services Administration prepared a draft Environmental Impact Statement(1)(EIS) for the proposed Library Complex. As part of this EIS, Walden Research performed an air quality impact modeling program for the proposed facility.

The principal objective of the impact analysis was to evaluate the maximum carbon monoxide (CO) levels which could arise as a consequence of both adverse meteorological conditions and peak roadway traffic in the project area. Although motor vehicles are also major contributors to community nitrogen oxide and reactive hydrocarbon emissions, these species participate in a series of complex photochemical reactions for which the current atmospheric diffusion modeling technology does not permit preparation of reliable estimates of projected concentration levels. Therefore, emphasis was placed principally on CO concentration levels as this pollutant is relatively inert. Other topics addressed in the analysis were the effects of an additional delay in Federal motor vehicle CO emission standards and nonimplementation of the Boston Transportation Control Plan (BTCP) on ambient air quality levels.

Background

Boston Transportation Control Plan

Under the Clean Air Act, all states were required to submit a State Implementation Plan for meeting the Federal ambient air quality standards set by the Environmental Protection Agency (EPA) in 1971. Transportation control measures are required for any air quality control region where Federal new car emission standards are inadequate to insure attainment or maintenance of the ambient standards. In general, two broad types of transportation controls have been considered: those which reduce emissions from individual motor vehicles such as installing control devices on each car, or those which reduce emissions from all vehicles as a class, such as by restrictions on vehicle travel. Most plans submitted to EPA by the states have employed a combination of strategies to meet the required air quality standards.

The Boston Transportation Control Plan (BTCP) has been designed to attain air quality standards in the Metropolitan Boston region by mid-1977. The BTCP has three main elements, all of which affect the project area:

(1) A semi-annual inspection and maintenance program to ensure that the pollution control equipment on each registered automobile remains in suitable working order.

(2) A requirement that two relatively low-cost pollution control devices, air bleed and vacuum spark advance disconnect, be installed on pre-1972 vehicles. The intent of this program is to reduce the most easily controllable sources of pollution from older motor vehicles.

(3) A program of incentives to reduce single passenger commuter automobile use including parking restrictions.

The impact of the BTCP in reducing vehicle emissions in the project area for future design years was included in the air quality impact analysis through adjustments to motor vehicle emission factors and to regionwide traffic volumes.

Diffusion Model

All predicted CO concentrations for this study were determined using the APRAC-1A urban diffusion model developed at the Stanford Research Institute.(2) The model simulates CO concentrations from readily available meteorological and traffic data. It is based on the Gaussian plume configuration and incorporates results from several recent research studies(3,4,5). Emission sources are specified in two forms: a primary network of traffic road segments or links, and a secondary grid of area sources. The model calculates pollutant concentrations from diffusion on various scales, ranging from extraurban diffusion of sources in upwind cities to intraurban diffusion of freeway, arterial and feeder street sources. In addition, a submodel handles the helical air circulation typical of urban street canyons. One-hour average CO concentrations are calculated as a function of time, for comparison and verification with observed concentrations and for operational applications.

A subprogram "VEHEMI" was integrated into the APRAC-1A program to determine more accurately CO vehicle emission rates. This algorithm is designed to compute explicitly the CO emission rate (grams/vehicle mile) for a specified motor vehicle model year mix, in this case, a mix typical of the Boston area. It replaced an empirical equation in APRAC-1A that was used for this purpose. The method is based on established EPA emissions estimation procedures(6), and incorporates such considerations as deterioration and speed adjustment factors. Recent changes in Federal motor vehicle emission standards related to amendments to the Clean Air Act and the effects of the retrofit device and inspection-maintenance elements of the BTCP were incorporated into estimates of emissions in future years.

Meteorological Input Data. It is generally agreed that the meteorological factors directly involved in predicting pollutant concentrations are transport and dilution by the mean wind, and dispersal by atmospheric turbulence (7). The dispersion properties of the atmosphere at any particular time can be described in terms of the joint occurrence of specific conditions of thermal stability, mixing depth, and wind. These meteorological factors are highly interrelated and are observed to occur in combinations of different conditions with varying frequency.

The APRAC-1A urban diffusion model used in this study to model air quality impacts is designed to be generally applicable to any city where conventional airport weather observations are taken. Airport surface wind speed and direction can be used directly. The method used for the mixing depth calculation is based on the 1200 GMT upper air temperature sounding of the National Weather Service (NWS). This sounding, together with the maximum afternoon temperature at the surface, permits the afternoon or maximum mixing depth to be calculated. The morning or minimum mixing depth is calculated by using a simple urban model and an empirical relationship involving city size and urban and rural nighttime temperatures. Hourly mixing depths are then interpolated on the basis of the observed hourly surface temperatures. The method used to determine the stability index depends on solar insolation, wind speed and cloud opaqueness.

Traffic Input Data. The diffusion model requires a traffic data base structured on two levels. First a high resolution primary network of road segments or links needs to be specified. Input parameters are the location, length, level of service and average daily traffic (ADT) for each link. Secondly, a grid of area sources to handle traffic emissions which do not require a high spatial resolution needs specification. Input here consists of the area and location of the grid squares and the 24-hour vehicle miles traveled (VMT) within each square.

A traffic data base representing the Metropolitan Boston region was created in this study for use in the APRAC-1A model. The primary link network was developed from ADT figures published in areawide traffic plans(8) for 1972 prepared by the Massachusetts Department of Public Works and based on actual traffic counts. The secondary grid of area sources was developed from VMT figures published in a report(9) in connection with the BTCP. This traffic data base was then scaled up to 1974 traffic levels using projected growth factors (10).

Aerometric Monitoring Program

In support of the model validation task described below, a comprehensive aerometric monitoring program was undertaken. Examination of the project area revealed two locations of prime interest for air quality measurements: at the project site at the intersection of Memorial Drive and Boylston Street, and at Harvard Square. The first of these sites was thought to be the point within the project where maximum public exposure to high CO levels might occur. The second site was estimated to be the location of a current CO maximum and is also a location where many visitors to the Library Complex are expected to gravitate. Air quality data was collected over a 60-day period in April, May and June of 1974 at these two receptor locations. At the project site, instrumentation was used to sample the ambient levels of carbon monoxide, sulfur dioxide, total suspended particulates and lead fraction. At the Harvard Square site, only carbon monoxide sampling was undertaken. In addition, hourly measurements of wind direction and wind speed were taken on-site during this time period. All measurements and operating procedures conformed with EPA referee procedures (11) and all resultant data was screened using EPA quality assurance criteria(12,13,14). Additional details can be found in the draft EIS(1).

Carbon monoxide was the only sampled pollutant species that exceeded ambient air quality standards. During the 60-day monitoring period, the Federal one-hour standard of 35 ppm was exceeded once. This condition occurred at the project site between 1700-1800 EDT on June 20, 1974, and the concentration was determined to be 35.6 ppm. This single concentration does not represent a violation of the standards, since the one-hour standard is not to be exceeded more than once per year. However, at both monitoring sites, the measurements showed the Federal eight-hour standard of 9 ppm being exceeded sixty to seventy percent of the time. Pollutant roses prepared from the measured data reveal significant channelization of emissions along Boylston Street from Harvard Square to the project site.

Traffic Data Base

Validation

In conjunction with the monitoring program, actual hourly traffic counts and turning distributions were recorded on five roadways near the two validation sites during April and May 1974. These data were used to specify the hourly percentage to be applied to the ADT on every link in the model. No vehicle speed measurements were made for this study. Instead, estimates of average traffic speeds for Metropolitan Boston by location (grid cell) and facility type were prepared from data in a BTCP report(9).

Impact Analysis

The traffic data required for the impact analysis was constructed in two stages. First, a determination was made of the base traffic that could be expected to normally occur in the project area for the time periods of interest. Next, projected library traffic associated with the highest project site visitation estimates were calculated and added to the base traffic. The 1974 traffic volumes and levels of service used in the validation study were chosen to represent the base traffic for the design years under consideration. The years considered in the project's impact analysis were 1978 and 1981. The first of these is the estimated year of completion and the expected peak year of project visitation, while the second is the first expected stable year in terms of visitors to the Library Complex. The 1974 traffic data was judged to constitute a reasonable, conservative estimate of the base traffic in the design years for two reasons:

(1) The projected levels(9) for base traffic in the project area in the design years are a reduction from 1974 levels due to the VMT reducing elements of the BTCP.

(2) These projections were made prior to the recent energy shortage and therefore, the possibility of additional reductions due to the current high prices of petroleum products were not considered.

Impact Analysis

Model Sensitivity

A sensitivity study of the modified APRAC-1A model as applied to the Metropolitan Boston area was conducted to determine the extent of the high resolution traffic link network required for vehicular emissions. In addition, a determination was made of the distance beyond which secondary grid area sources had no discernable effect on the CO concentrations in the project area.

It was found that vehicular CO sources beyond a radius of three miles from the project site had no discernable effect on the CO concentrations in the project area. Therefore, all area sources beyond this distance from the project site were removed from the traffic data base. Note that downtown Boston, the area of peak CO emissions density in the region, falls within this three-mile radius. By systematically removing the outer traffic links and pooling their emissions in grid area sources, it was also found that beyond a radius of seven-tenths of a mile, the resolution of a link network did not significantly effect the results and hence, was unnecessary.

Model Validation

For the purpose of verifying the accuracy of the diffusion model in predicting CO concentrations for the Boston region and the project area in particular, a model validation exercise was performed. This entailed modeling the region for CO concentrations during several time periods for which on-site CO, traffic, and meteorological measurements were available, comparing the results statistically, and drawing conclusions. By assimilating these on-site measurements, along with other meteorological data (surface temperatures, cloud cover, upper air soundings) from the NWS station at Boston's Logan Airport, a set of one-hour periods in late April and early May was selected for use in validation of the model. Since upper air soundings at Boston were discontinued by the NWS over a year ago, it was necessary to obtain this data from Portland, Maine. Both cities experience similar mixing height characteristics on a given day; consequently, the substitution does not affect the validation results significantly. Excluded from this data set were many periods during which large shifts in the wind direction and speed occurred, as might be associated with the passage of a front or the onset of a local sea-breeze circulation. During these transition periods, a Gaussian diffusion model based on the assumption of an hourly mean wind speed and direction would be expected to perform poorly. Also excluded were time periods after 2200 EDT and before 0700 EDT as maximum CO concentrations always occur in conjunction with daytime traffic patterns in the project area.

From this set of one-hour validation periods (37 for the project site and 15 for the Harvard Square location), a random sample of 12 periods for each of the two validation sites was chosen with the constraint that no particular wind direction be favored in the resultant data set if at all possible. In both cases, a statistical t-distribution significance test for small samples was applied to insure that the chosen set was a representative sample. These 24 one-hour periods formed the basis of the model validation. An example of the data screening procedure is shown for the project site in Table I.

The submodel in APRAC-1A for street canyons was used at both validation sites. At each, urban structures ranging in height from 15 to 40 meters produce a significant effect on the aerodynamic flow. Studies have shown the effects of entrapment and downwash in urban areas can cause pollutant concentrations to vary as much as a factor of three from one side of a street to the other[2]. Receptors on the leeward side of a building are exposed to substantially higher concentrations than are those on the windward side because of a reverse flow component across the street, near the surface. Even though neither validation site has the configuration of a simple street canyon as assumed in the model, inclusion of the submodel in validation runs modeled at least the macroscale characteristics of this phenomena. Model calculations for the canyon option were based on traffic data for the roadway link on which the receptor was located.

To evaluate the validation results, a linear regression was done between the measured and predicted CO concentrations for the 24 one-hour periods (see Figure 1). The data gave a correlation coefficient of $r = 0.90$. This value is interpreted quantitatively by stating[15] that r squared is equal to the percentage of the variance of the predicted concentrations that can be accounted for by a linear relationship with the measured concentrations (82%). The remaining percentage (18%) is referred to as the error variance due to other factors, as described below. Therefore, it was concluded that the data from the Harvard Square and Library Complex receptor sites have a highly acceptable correlation coefficient (i.e., excellent validation).

The accuracy of the CO predictions made in the model validation were highly dependent on a number of factors related to the analysis methodology employed. The major sources of uncertainty associated with the analysis were:

- Accuracy of the atmospheric diffusion model
- Variability of the micrometeorology
- Accuracy of the traffic volume data
- Errors in measuring CO levels and meteorological parameters
- Potential bias in representative sample used for validation

Model Calibration

The purpose of a calibration is to incorporate into the impact modeling program information concerning the relationship between measured (χ_m) and predicted (χ_p) CO concentrations uncovered by the model validation. This is accomplished by fitting the validation results to a straight line whose slope and intercept are then used as correction factors in making future predictions. The scatter diagram depicting the relationship between χ_m and χ_p in the validation exercise is shown in Figure 1. By the method of least squares, the linear regression of χ_m on χ_p was found to be $\chi_m = 1.08 + 0.98 * \chi_p$ (solid line in Figure 1). This equation was used to calibrate the model for the actual impact-modeling program.

Emissions Summary

Motor vehicle CO emission factors for 1978 and 1981 as estimated by the VEHEMI subprogram are shown in Table II distributed by calendar year and average vehicle speed. The sharp decrease in emissions from 1974 to 1978 is due to two factors. First, the shift of the vehicle population to newer models will replace the oldest four year segment (uncontrolled) of the model year mix by newer models (controlled). CO emissions for these controlled vehicles are approximately 96% less than those from uncontrolled vehicles. Second, implementation of the BTCP retrofit device and inspection-maintenance programs will further reduce each motor vehicle's emissions depending on the model year. The exact percentage reductions used were estimates from recent EPA research and development efforts(16).

Four time periods were chosen for the impact modeling analysis (see Table III). The first of these, a May weekday in 1978, represents the combined peak one-hour traffic volume in the peak year, i.e., the worst case. This time period was evaluated as both a No-Build and Build alternative. Three additional Build cases in 1978 and 1981 were also evaluated. All cases used the one- and eight-hour periods of the designated day for which peak traffic is projected. Using the emission factors shown in Table II, total vehicular emissions were compiled for the peak one- and eight-hour periods in each case for the modeled roadway links within a seventh-tenth of a mile radius of the project site. The results are also shown in Table III.

.Predicted Air Quality

Assumptions. Detailed modeling simulations were conducted for the five impact modeling cases summarized in Table III. The "worst-worst" case was assumed in each instance, i.e., the joint occurrence of peak traffic and most adverse meteorological conditions. The meteorological conditions responsible for high ground-level pollutant concentrations associated with poor atmospheric dispersion of ground-based emission sources are a shallow mixing depth, low wind speed and a stable atmospheric thermal structure. The daytime meteorological conditions chosen to represent poor atmospheric dispersion were a mixing depth of 100 meters, a mean wind speed of 1.0 meters per second and a Pasquill's atmospheric stability class "D"(7). The 100 meter mixing depth is a typical value corresponding to the top of the turbulent surface boundary layer in an urban area. A mean wind speed of 1.0 meters per second is the minimum value that can be meaningfully used in the Gaussian plume equations in the APRAC-1A model. Class "D" represents the most stable ground-level atmospheric stability characteristic of urban areas during the daytime periods associated with the impact modeling cases. The APRAC-1A model was applied to predict one-hour maximum carbon monoxide (CO) concentrations in the project area. To obtain eight-hour concentrations, a highly conservative assumption was made that the meteorological conditions responsible for the one-hour maxima persist over an eight-hour interval. This assumption allowed direct scaling of the predicted one-hour maxima by appropriate traffic volumes to predicted worst case eight-hour concentration levels. No scaling of the concentrations to account for the lengthening of the concentration averaging time (peak-to-mean ratios) was considered by this approach. Predictions of pollutant

concentrations were made at 27 selected sensitive receptor locations in the project area where maximum public exposure to high CO levels is anticipated. These sites were located in residential and commercial districts, and near schools, colleges, museums and parks.

Results. The results of the modeling simulations for all five cases show that maximum CO concentrations within the project area will be below all applicable air quality standards when the Library Complex opens in 1978 and in the future design year of 1981. The highest predicted levels occurred in Harvard Square and on the project site at the Memorial Drive-Boylston Street intersection. These are the two locations where the highest concentrations were expected to occur and where the instrumentation for the ambient monitoring program was located. In Harvard Square, the predicted one- and eight-hour maxima are 9.4 ppm and 7.4 ppm, respectively. At the project site, these values are 8.3 ppm and 6.5 ppm. This contrasts greatly with the results of the ambient monitoring program where measurements showed the Federal eight-hour CO standard being exceeded 60 – 70% of the time during a 60-day sampling period in 1974. The cause of this predicted improvement in air quality levels is the anticipated drop in CO vehicle emission factors in 1978 to almost one-third of their 1974 levels (see Table II). The results of the impact modeling were summarized in a series of pollutant isopleth maps for inclusion in the EIS(1).

In order to determine the differential impact of the project on community air quality, the diffusion model was used to perform an analysis of the minimum increase over base traffic in Case 1a necessary to exceed the standards at the two critical receptor locations. The results are summarized in Table IV. Here it can be seen for the worst case that the projected increase in traffic associated with the Library Complex is insignificant compared to that required to produce a violation of the air quality standards. This conclusion is based on the assumption that the Federal motor vehicle emission standards for CO will not be further delayed beyond the current deadline of 1977 and that the BTCP will be implemented as currently planned. Surprisingly, it was found that an additional two year delay of Federal auto emission standards would not significantly increase the predicted ambient air quality levels. However, if the BTCP is not fully implemented by 1978, the worst case predicts violation of the eight-hour standard in the project area in 1978 using base traffic alone. Nevertheless, in this instance, the projected small traffic increment associated with the Library Complex will not significantly affect attainment of the one-hour standard.

The modeling projections were based on conservative assumptions at each step in the analysis. Specifically:

- The "worst-worst" case was assumed in each instance, i.e., the joint occurrence of peak traffic and poor atmospheric dispersion.
- The joint frequency of occurrence of the meteorological conditions assumed for poor atmospheric dispersion is very small. From a recent five year record (1966 – 1970) of climatological data gathered by the NWS at Boston's Logan Airport, the annual joint probability

of occurrence of class "D" stability and low wind speed was found to be only 0.00122. This is equivalent to only 10.7 one-hour periods throughout the entire year. In addition, the average mixing depth in Boston is 789 meters(17), and so the joint probability of occurrence of a low 100 meter mixing depth with the other two parameters is diminishingly small.

- The atmospheric conditions responsible for the one-hour maxima were assumed to persist over an eight-hour interval.
- The eight-hour concentrations were not scaled by peak-to-mean ratios of the concentration averaging times.

Conclusion

Modeling of the indicated cases reveals that construction of the Library Complex will not interfere with the attainment or maintenance of air quality standards in the project area. Thus, the project was judged consistent with the State Implementation Plan.

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Table I. Hourly periods for which data was available at the project site validation station*

WIND SPEED AND DIRECTION	UPPER AIR SOUNDING (1200GMT)	TRAFFIC COUNTS	CO MEASUREMENTS	VALIDATION SET AFTER EXCLUSIONS	CHOSEN SAMPLE
11-24	x				
x	x	x	x		
x	x	14-24	x	14-19	16-19
x		00-15	x		
x	x	08-12,18-19	00-10		
00-18,19-24	x	18-24			
00-18	x	00-13	10-24	09-13	10-13
08-24		14-18	x		
x	x	07-16	x	7-13,14-16	
x	x	19-24	00-15		
00-20,21-24	x	x	09-24	09-19	09-11,17-1
00-15,16-18,19-24	x	00-04,09-15,19-20	x	09-14,19-20	
00-18		20-24	x		
	x	00-21	x		
x	x	07-11,14-24	x	07-11	07-10
00-13	x	00-14,19-24	x		
10-24	x	00-09	x		
x	x		x		
00-18	x		x		
04-08	x		x		
10-11,14-24	x		x		
00-08,09-11,12-24	x		x		
x	x				
00-12,18-22,23-24	x				
x	x				

ased on a 24-hour time period.
data complete

Table II. Emission factors for carbon monoxide (in gms/vehicle mile) for calendar years 1974, 1978 and 1981 in Metropolitan Boston distributed by average vehicle speed*

	Vehicle Speed (mph)			
Calendar Year	15	20	30	40
1974	66.0	51.8	36.2	29.6
1978	23.6	20.1	16.1	14.5
1981	16.1	14.8	13.3	12.6

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*Based on Metropolitan Boston motor vehicle model year mix.

Table III. Emissions of carbon monoxide within a 0.7 mile radius of the proposed J.F. Kennedy Memorial Library in one-hour and eight-hour periods for the designated air quality impact evaluation cases

Case Number	Calendar Year	Month/Day	Time Period		CO Emissions (tons)	
			One-Hour	Eight-Hour	One-Hour	Eight-Hour
1	1978	May Weekday	4:00 – 5:00 pm	11:30 – 7:30 pm	0.57	3.53
1a*	1978	May Weekday	4:00 – 5:00 pm	11:30 – 7:30 pm	0.55	3.43
2	1978	August Weekday	4:00 – 5:00 pm	11:30 – 7:30 pm	0.50	3.15
3	1981	August Weekday	4:00 – 5:00 pm	11:30 – 7:30 pm	0.37	2.33
4	1981	August Saturday	2:00 – 3:00 pm	11:30 – 7:30 pm	0.32	2.14

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*No-Build Case

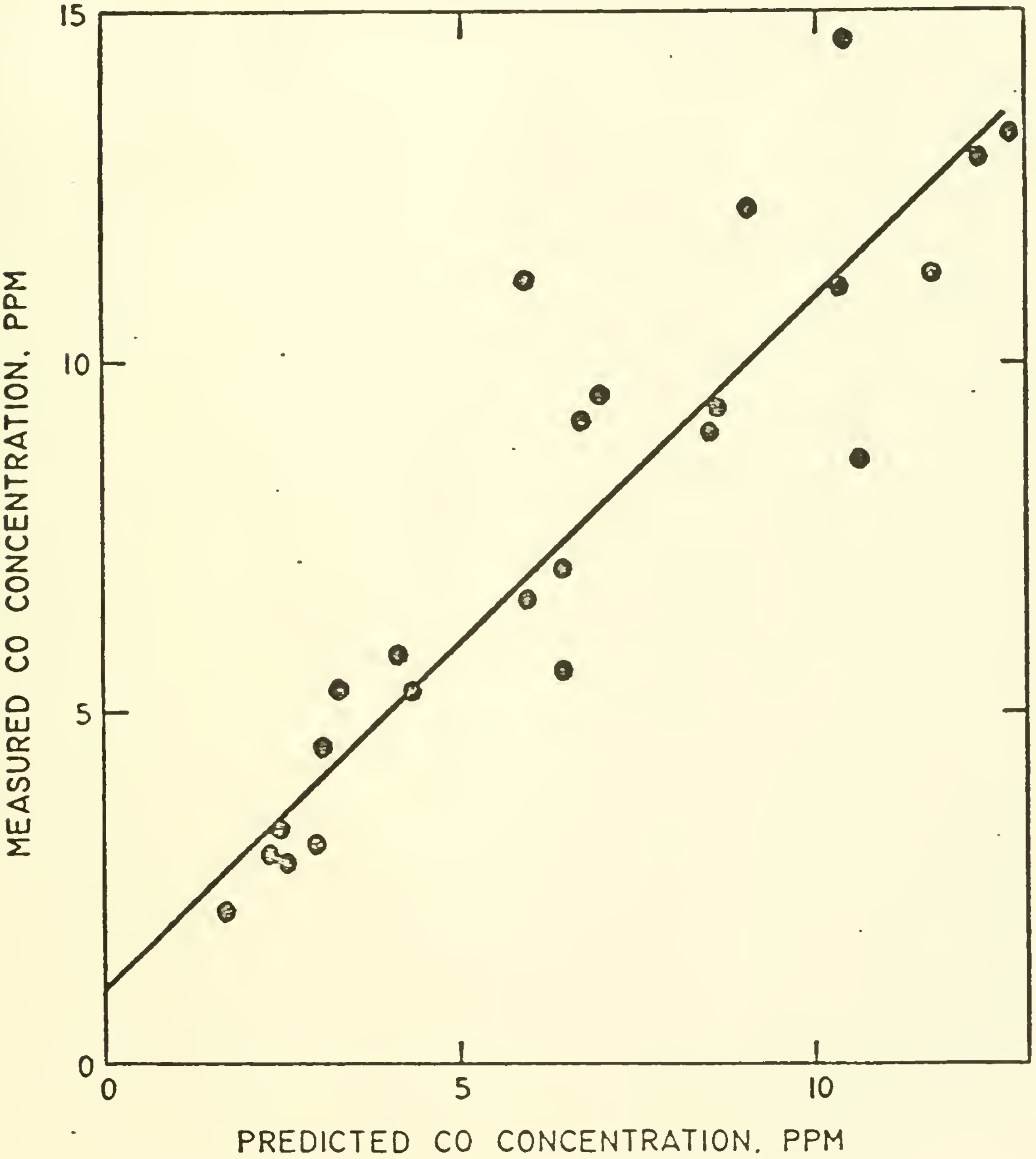
Table IV. Percentage increase in motor vehicle traffic over base traffic necessary to exceed carbon monoxide standards and actual projected library traffic for the worst case

Receptor Location	Air Quality Standard Averaging Time One-Hour	 Eight-Hour	Actual Projected Library Traffic as a Percentage Increase Over Base Traffic (Case 1)
Harvard Square	418%	29%	1%
Project Site	603%	67%	3%

Captions

Figure 1. Comparison of measured and predicted one-hour CO concentrations.

FIGURE 1. COMPARISON OF MEASURED AND PREDICTED ONE-HOUR CO CONCENTRATIONS



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